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(54) **PLASMA DISPLAY DEVICE HAVING EFFICIENT HEAT CONDUCTIVITY**

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(57) **ABSTRACT**

A plasma display device including a plasma display panel, a chassis base proceeding substantially parallel to the plasma display panel, and a heat conductive medium closely adhered to the plasma display panel and the chassis base while being disposed between the plasma display panel and the chassis base. The side of the heat conductive medium facing the plasma display panel and/or chassis base is provided with a plurality of prominent portions. Depressed portions are disposed between the prominent portions to remove the gap between the heat conductive medium and the respective plasma display panel and/or chassis base. Contact area enlargement members are formed at the prominent portions to improve the attachment efficiency of the heat conductive medium to the respective plasma display panel and/or chassis base.

APPENDIX H

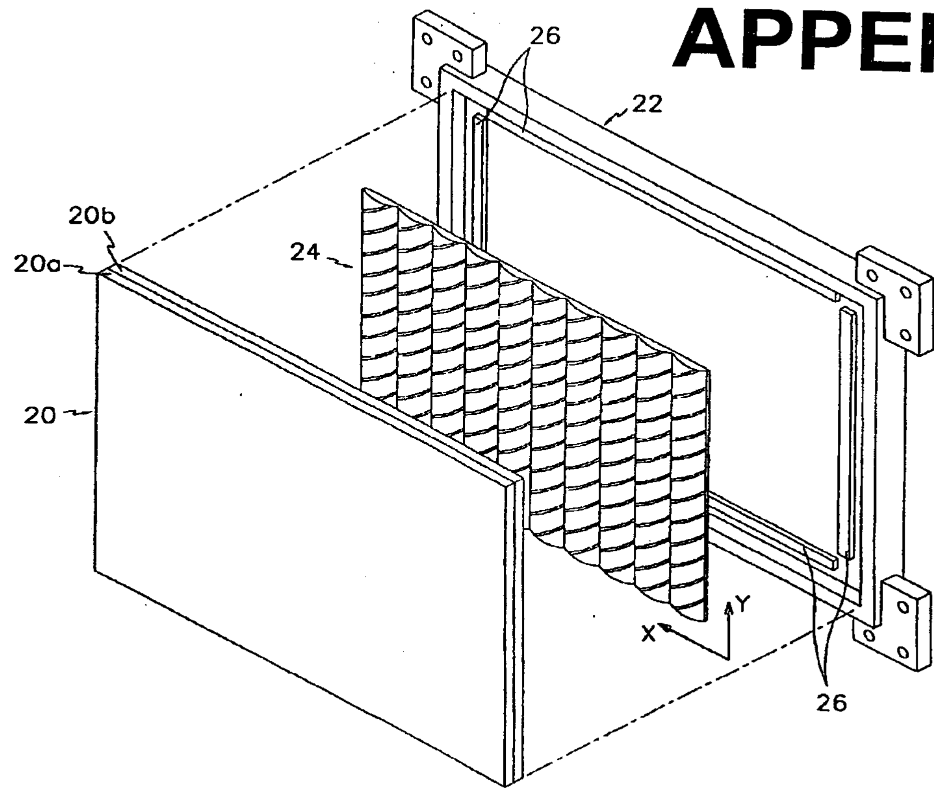


FIG. 1

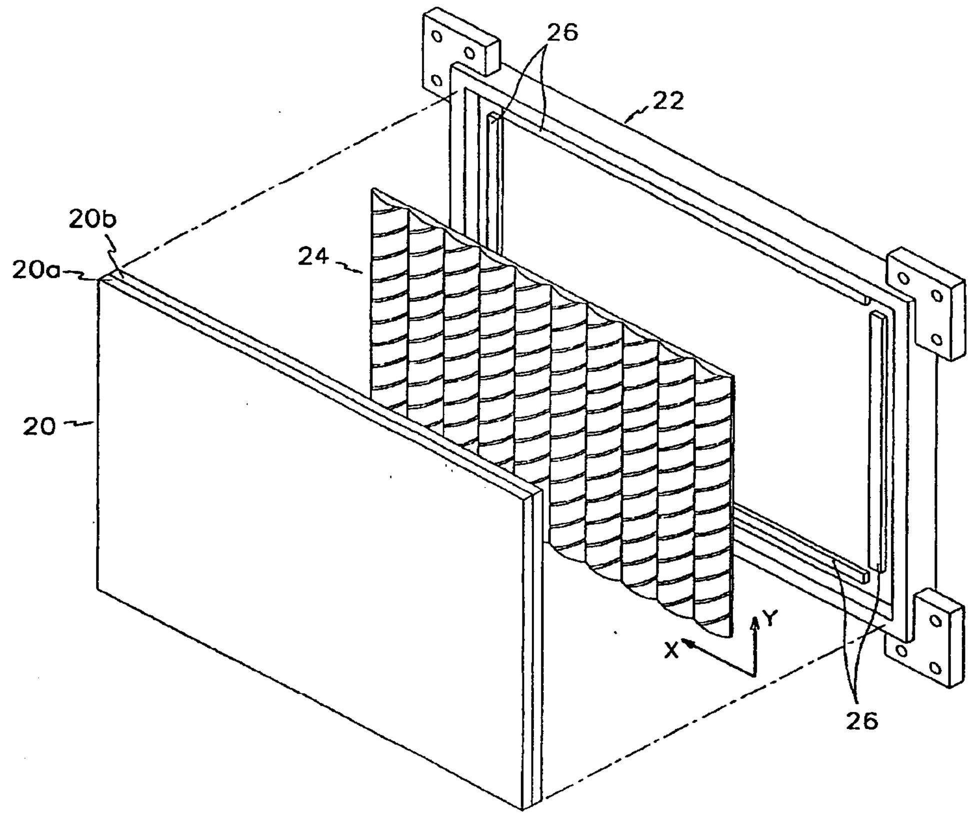


FIG. 2

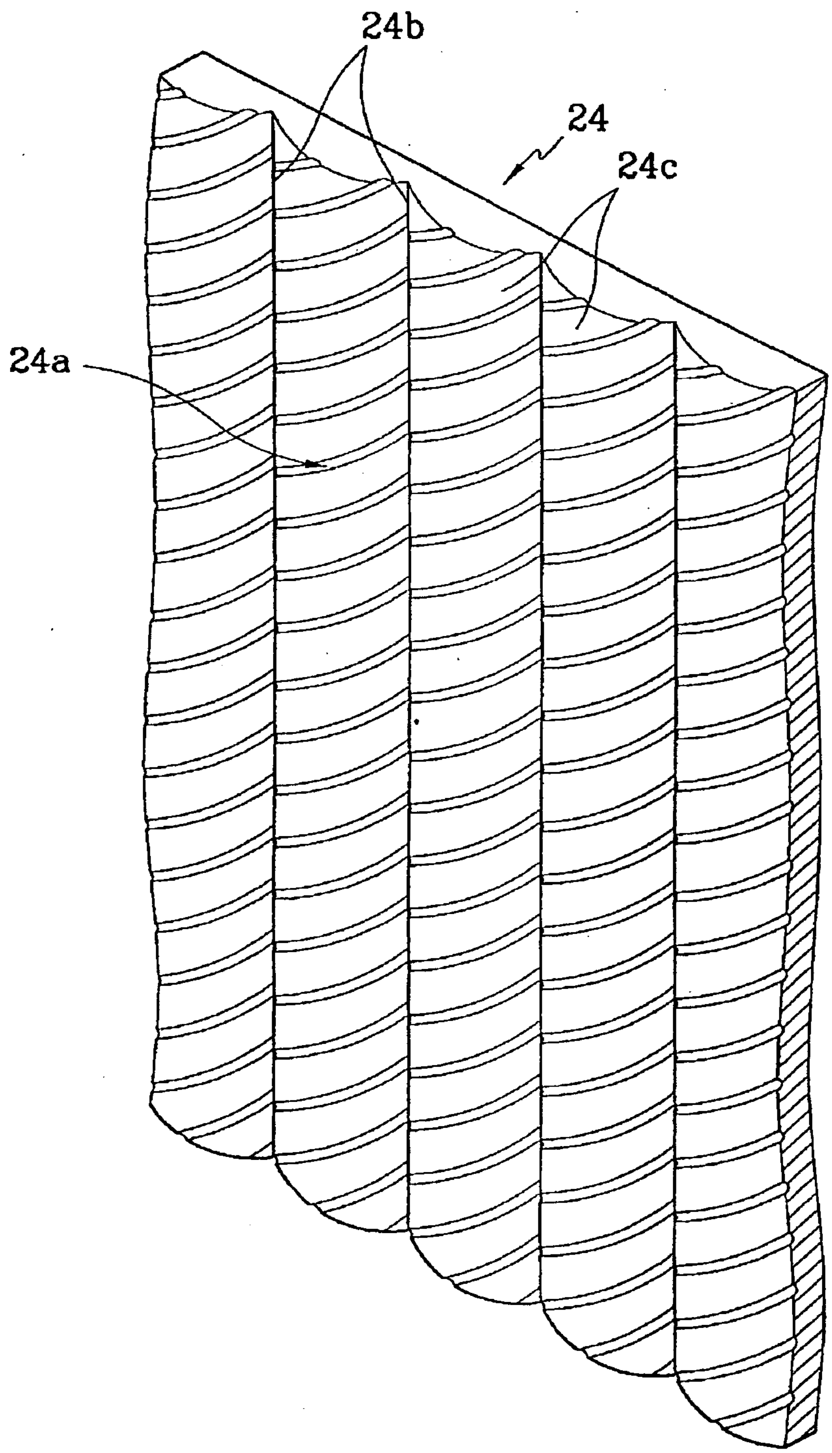


FIG. 3A

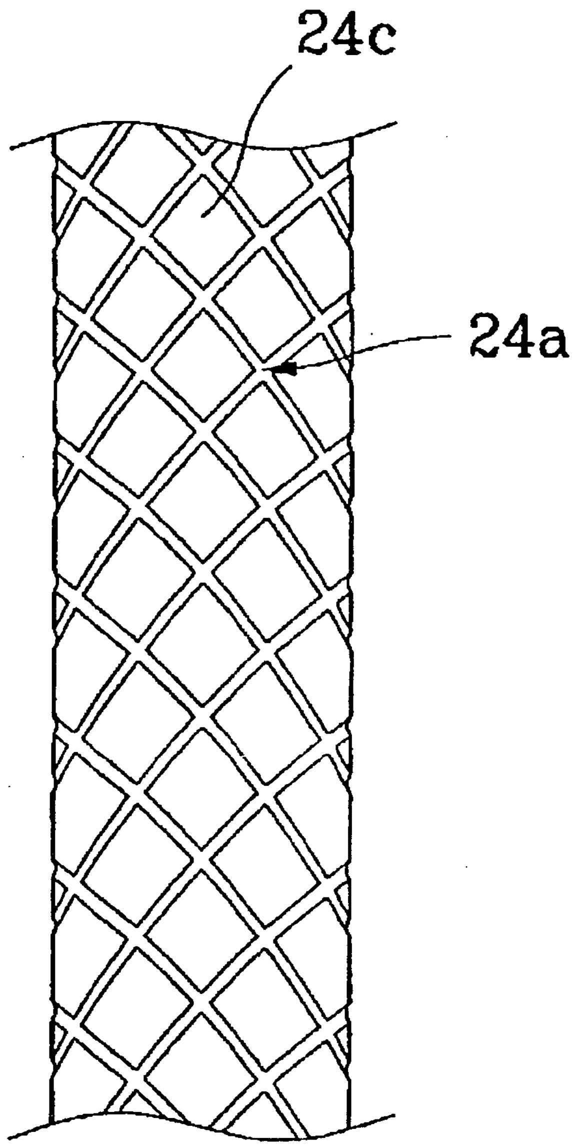


FIG. 3B

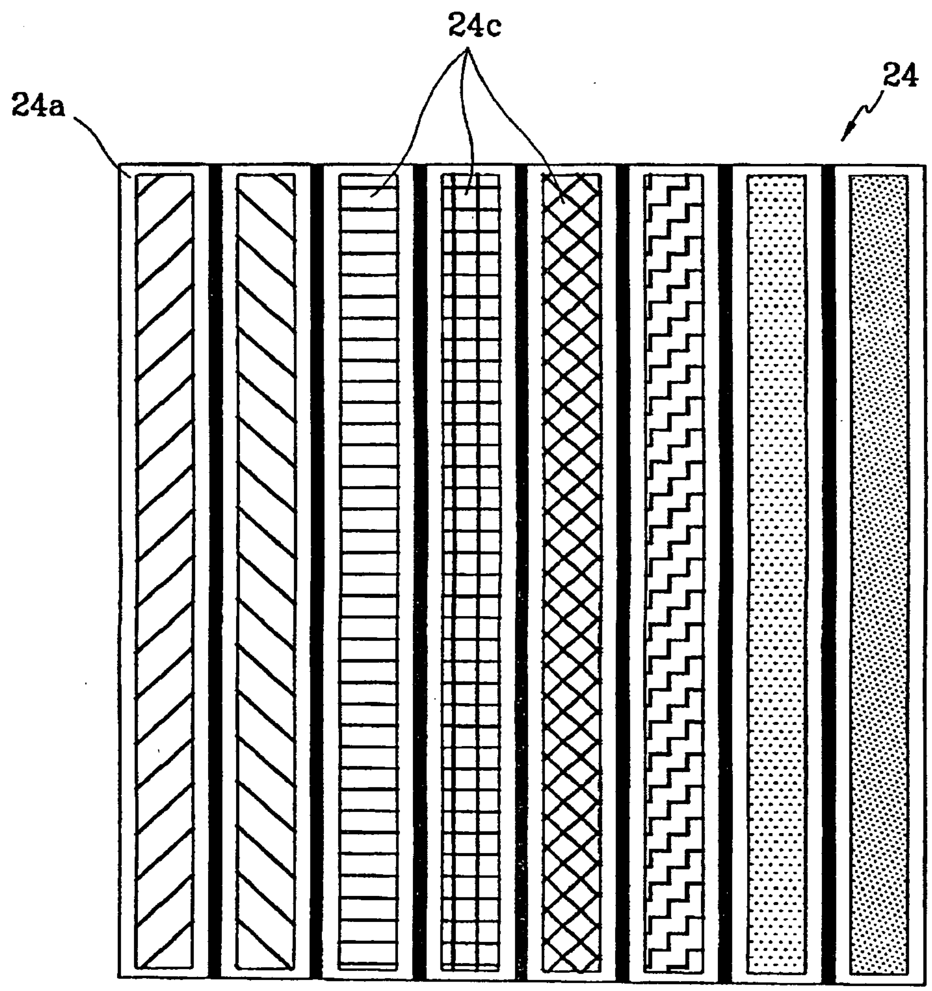


FIG. 4A

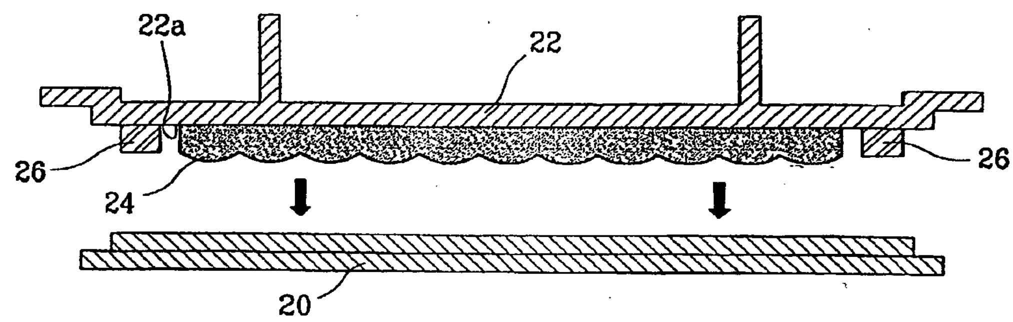


FIG. 4B

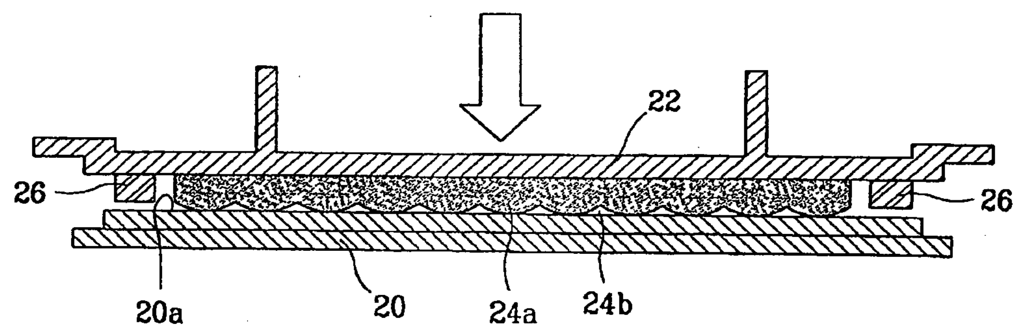


FIG. 4C

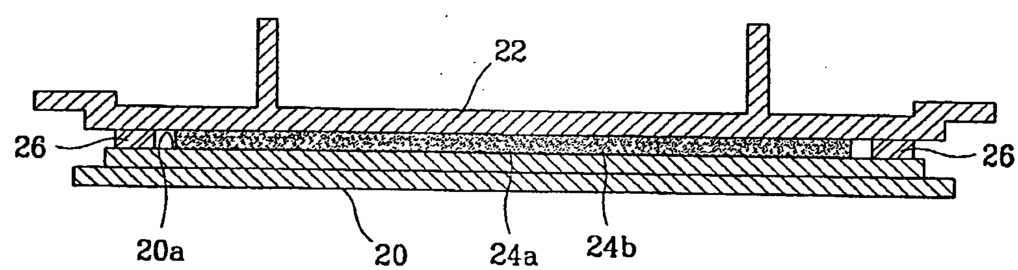


FIG. 5

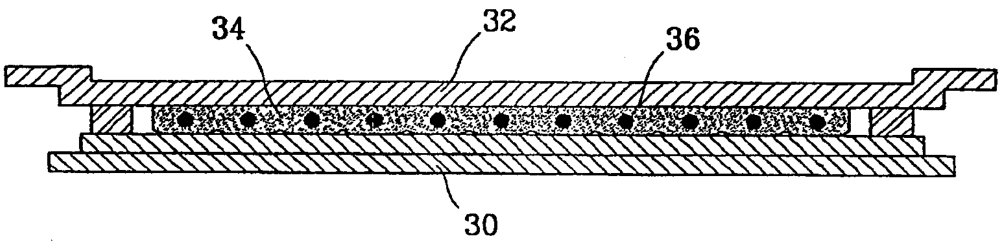


FIG. 6A

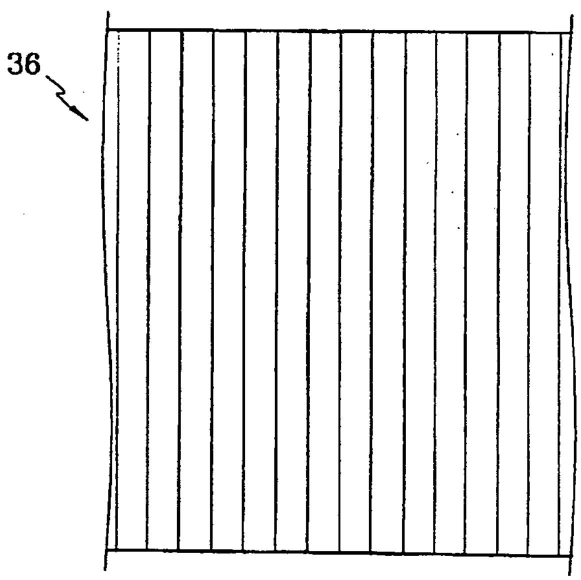


FIG. 6B

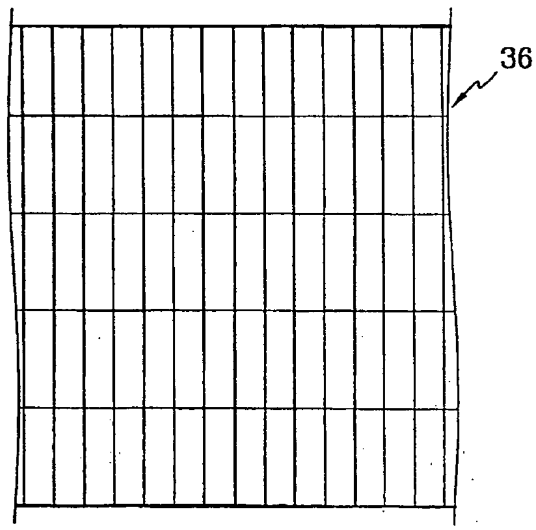


FIG. 7

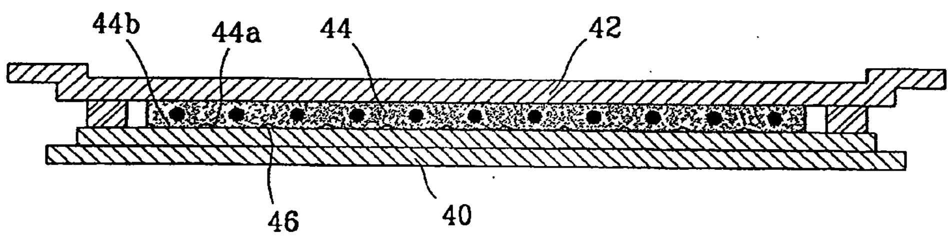


FIG. 8

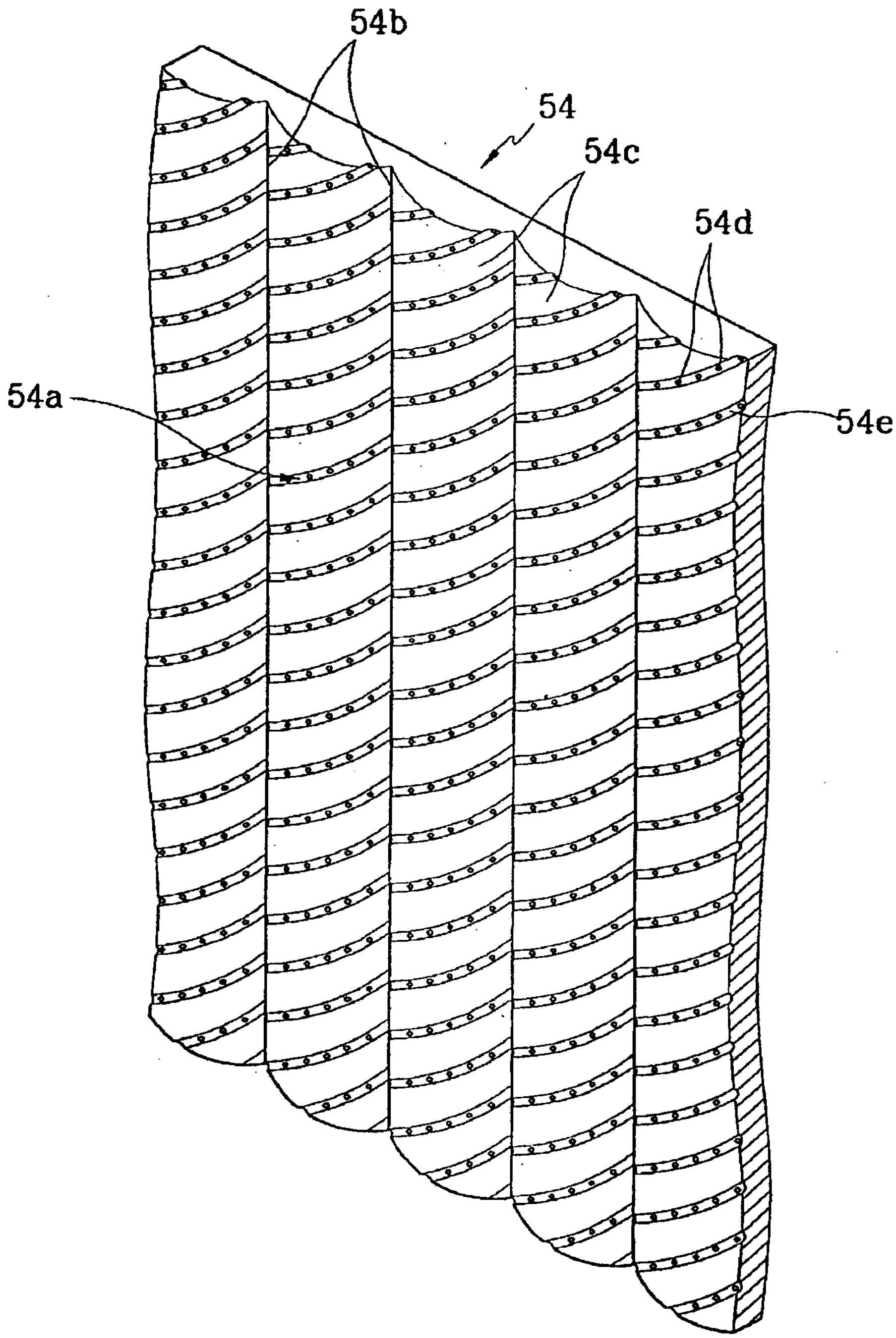


FIG. 9

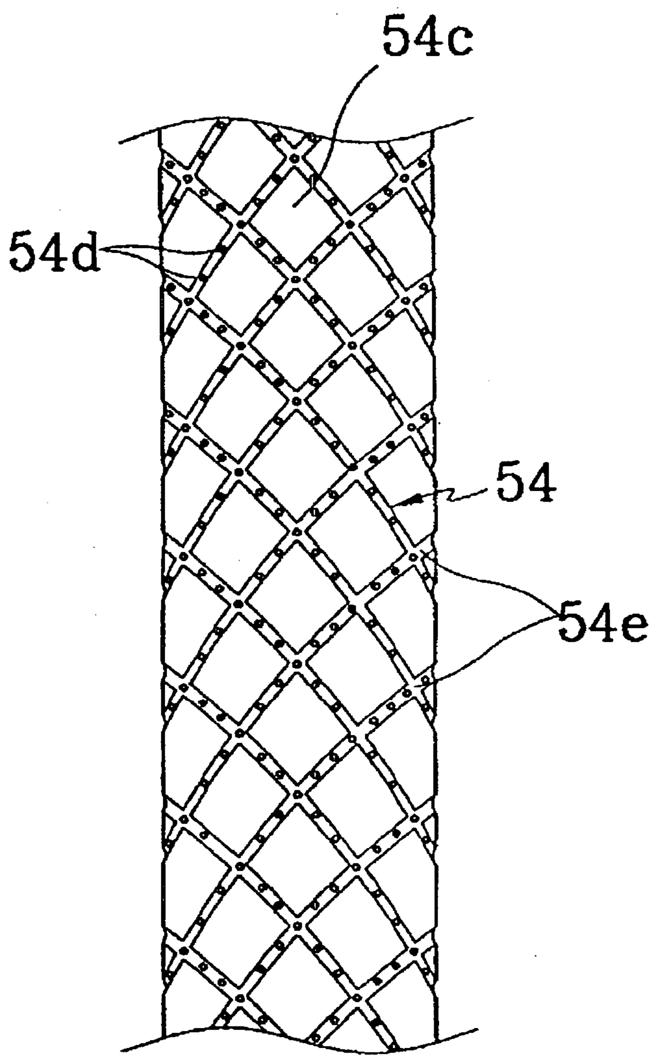


FIG. 10A

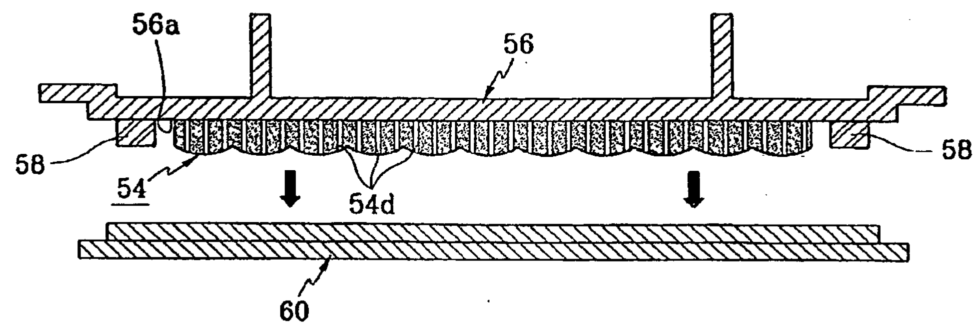


FIG. 10B

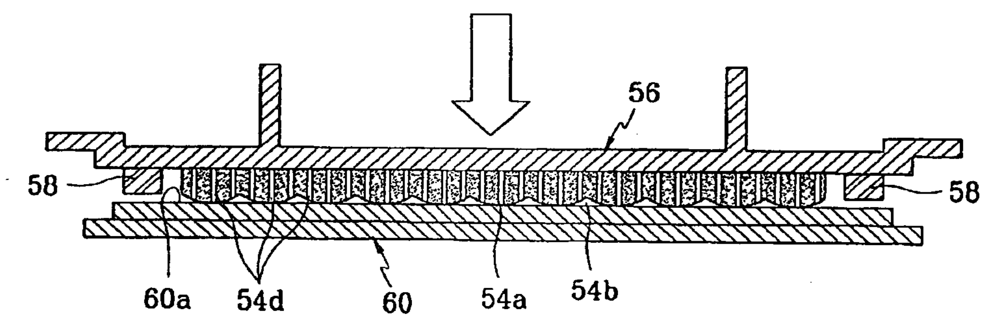
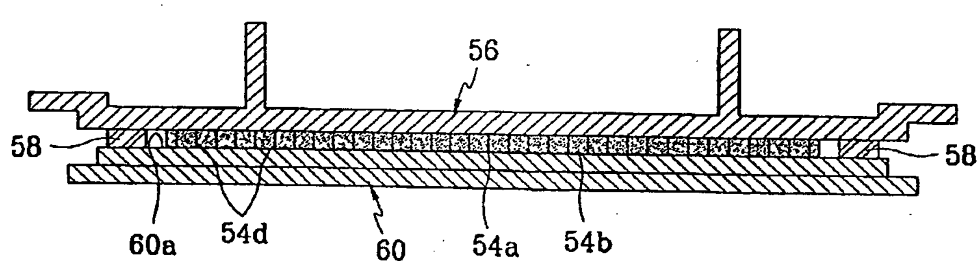


FIG. 10C



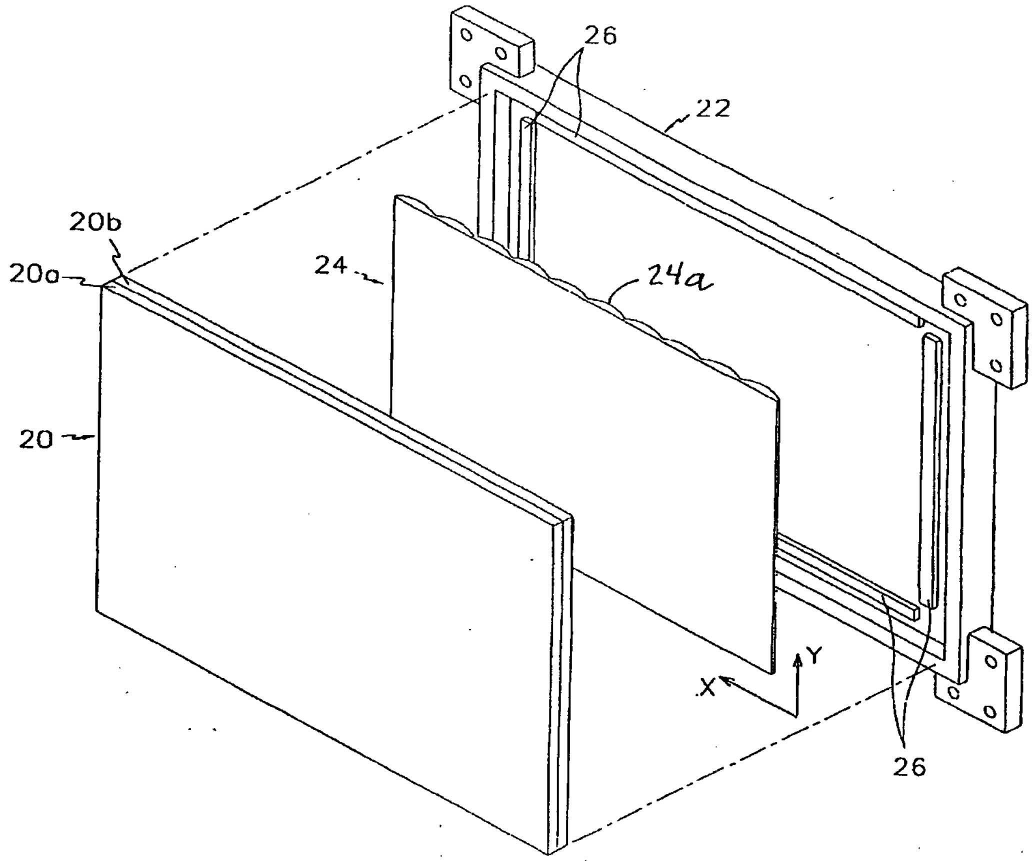


FIG. 11

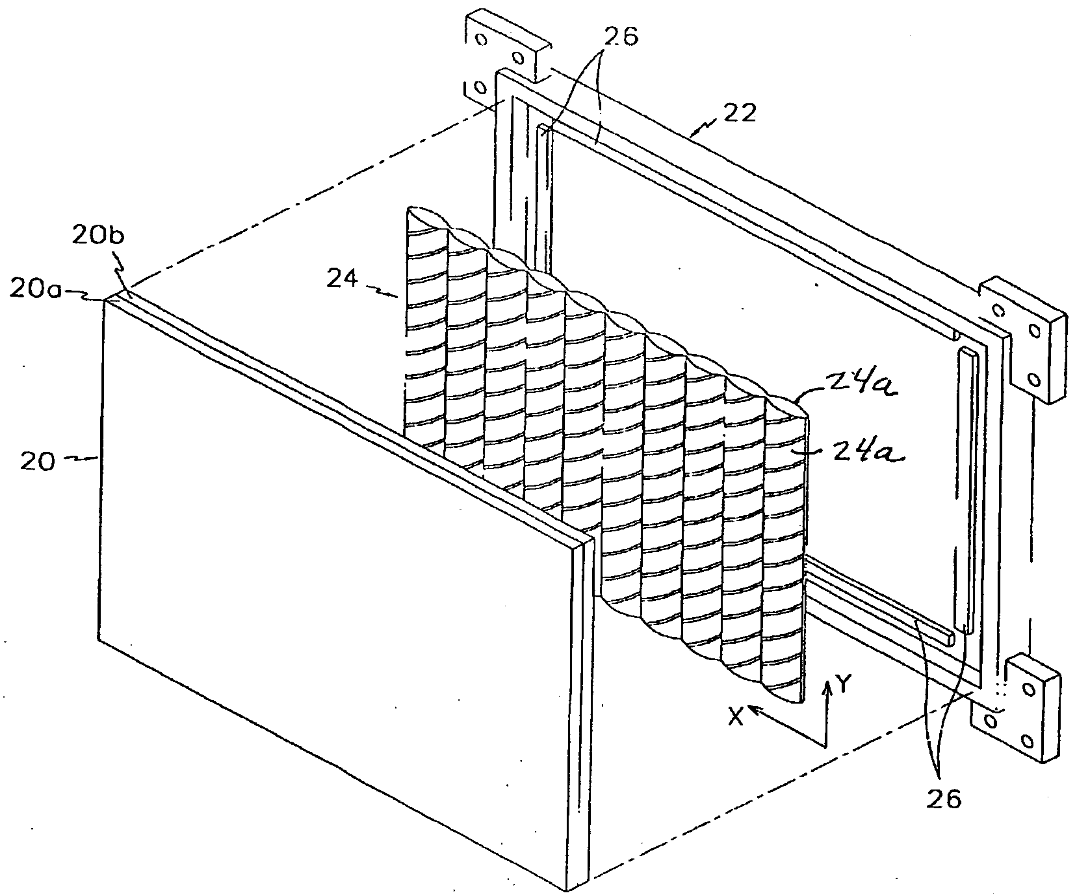


FIG. 12

PLASMA DISPLAY DEVICE HAVING EFFICIENT HEAT CONDUCTIVITY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of Korean Application No. 2001-47072, filed on Aug. 3, 2001 and No. 2001-63455, filed on Oct. 15, 2001 in the Korean Patent Office, the entire disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to a plasma display device and, more particularly, to a plasma display device that has a heat conductive unit for dissipating the heat generated at the plasma display panel to the outside.

BACKGROUND OF THE INVENTION

[0003] Generally, a plasma display device involves a plasma display panel (PDP) where heat is generated due to the discharge gas. The heat generated at the PDP becomes heightened with the increase in brightness. Therefore, it is a critical factor in the plasma display device to dissipate to the outside in an effective manner the heat generated at the PDP.

[0004] For that purpose, the PDP is attached to a chassis base having an excellent thermal conductivity, and a heat spreading sheet (or heat conductive seat) is provided between the PDP and the chassis base such that the heat generated at the PDP is dissipated to the outside via the heat conductive seat and the chassis base. The chassis base is typically formed with a metallic material such as aluminum by die casting or pressing. The heat conductive seat is typically formed of acryl or silicon-based resin.

[0005] For heat conduction efficiency the installation state of the heat conductive seat becomes very important because the heat conduction efficiency can be heightened only if the heat conductive seat is closely adhered to the PDP and the chassis base.

[0006] However, the side of the chassis base contacting the heat conductive seat cannot be completely flattened, but may be slightly curved or protruded due to the processing conditions. Consequently, when the heat conductive seat contacts the non-flattened side of the chassis base, a gap is made between the heat conductive seat and the chassis base, and is filled with air.

[0007] When the plasma display device is manufactured such that air is present between the chassis base and the heat conductive seat, the desired heat conduction cannot be made in view of the air so that the overall thermal conduction rate and the heat dissipation efficiency become deteriorated. Such a problem occurs at the contact area between the chassis base and the heat conductive seat as well as at the contact area between the PDP and the heat conductive seat.

[0008] In order to solve such a problem, when the heat conductive seat is attached to the PDP or the chassis base, the pressurizing power applied to the heat conductive seat may be increased while enhancing the adhesive strength. However, in this case, an impact is applied to the PDP due to the increased pressurizing power so that the partitioning wall thereof can become damaged and cause device failure.

[0009] Japanese Patent Publication Laid-open No. Hei10-254372 discloses a plasma display device where prominence and depression are formed at the contact area between the heat conductive seat and the PDP to remove the gap between them. When the heat conductive seat is pressurized onto the PDP, the prominent portion becomes pressed to the depressed portion while flattening the depressed area and allow the air in the depressed portion to escape to the outside.

[0010] However, it is practically difficult to make the side of the PDP or the chassis base contacting the heat conductive seat be completely flattened. Furthermore, when pressurizing power to the heat conductive seat is increased to enhance the adhesion efficiency, the partitioning wall of the PDP may be damaged while causing device failure. Therefore, a need exists for a plasma display device which can enhance efficiency in the adhesion of the heat conductive seat even though the contact side of the heat conductive seat is not completely flattened. The present invention provides a solution to meet such need.

SUMMARY OF THE INVENTION

[0011] In accordance with the present invention a plasma display device is provided which can enhance efficiency in the adhesion of the heat conductive seat while not increasing the pressurizing power to the heat conductive seat.

[0012] The plasma display device includes a plasma display panel, a chassis base proceeding substantially parallel to the plasma display panel, and a heat conductive medium closely adhered to the plasma display panel and the chassis base while being disposed between the plasma display panel and the chassis base. The side of the heat conductive medium facing the plasma display panel and/or chassis base is provided with a plurality of prominent portions. Depressed portions are disposed between the prominent portions to remove the gap between the heat conductive medium and the respective plasma display panel and/or chassis base. Contact area enlargement members are formed at the prominent portions to improve the attachment efficiency of the heat conductive medium to the respective plasma display panel and/or chassis base.

[0013] The prominent portions of the heat conductive medium are formed as a plurality of longitudinally parallel convex portions. The contact area enlargement member can be formed by three-dimensional pattern separated by a groove. The three-dimensional pattern can be formed as a diamond-like shape, or as a comb teeth shape.

[0014] A gel-state heat conductive member can be formed at the depressed portions. The gel-state heat conductive member can be formed with grease.

[0015] The plasma display device further includes a reinforcing member formed at the heat conductive medium to reinforce the hardness of the heat conductive medium. The reinforcing member can be formed with micro-fibers or micro-metals built into the heat conductive medium while bearing a predetermined pattern.

[0016] A plurality of holes are formed at the prominent portions while passing through the prominent portions. The holes are arranged at grooves of the prominent portions outlining a contact area enlargement member. The holes are formed with a circular shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] **FIG. 1** is an exploded perspective view of a plasma display device according to a first embodiment of the present invention.

[0018] **FIG. 2** is a partial amplified view of the plasma display device shown in **FIG. 1** illustrating the structure of a heat conductive medium.

[0019] **FIGS. 3A and 3B** are plan views illustrating a contact area enlargement member of the heat conductive medium shown in **FIG. 2**.

[0020] **FIGS. 4A** to **4C** illustrate the steps of combining the structural components of the plasma display device shown in **FIG. 1**.

[0021] **FIG. 5** is a cross sectional view of a plasma display device according to a second embodiment of the present invention.

[0022] **FIGS. 6A and 6B** are plan views illustrating a pattern of a reinforcing agent for the plasma display device shown in **FIG. 5**.

[0023] **FIG. 7** is a cross sectional view of a plasma display device according to a third embodiment of the present invention.

[0024] **FIG. 8** is a cross sectional view of a heat conductive medium for a plasma display device according to a fourth embodiment of the present invention.

[0025] **FIG. 9** is a partial plan view illustrating a variation in the heat conductive medium shown in **FIG. 8**.

[0026] **FIGS. 10A** to **10C** illustrate the steps of combining the structural components of the plasma display device shown in **FIG. 8**.

[0027] **FIG. 11** is an exploded perspective view of a plasma display device according to a further embodiment of the present invention.

[0028] **FIG. 12** is an exploded perspective view of a plasma display device according to a still further embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] **FIG. 1** is an exploded perspective view of a plasma display device according to a first embodiment of the present invention.

[0030] As shown in **FIG. 1**, the plasma display device includes PDP **20** with two sheets of glass substrates *20a* and *20b*, chassis base **22** fitted to PDP **20** while being positioned at the rear side of PDP **20** opposite to the display screen side thereof. Heat conductive medium **24** is disposed between PDP **20** and chassis base **22** to transfer the heat generated at PDP **20** to chassis base **22**. A front case (not shown) is provided to the side of PDP **20**, and a back case (not shown) is provided to the side of chassis base **22**, thereby constructing the plasma display device.

[0031] In the above structure, PDP **20** has a rectangular shape with long and short axes. Chassis base **22** is formed from aluminum which has an excellent thermal conductivity. A circuit unit is fitted to a side of chassis base **22** opposite to the side thereof in contact with PDP **20** to drive the plasma display device.

[0032] Heat conductive medium **24**, together with chassis base **22**, have the role of dissipating to the outside the heat generated at PDP **20** due to the operation of the plasma display device. In order to enhance efficiency in the adhesion of heat conductive medium **24** to chassis base **22** or PDP **20**, heat conductive medium **24** has a structure with the following features.

[0033] Heat conductive medium **24** is formed with a soft material such as silicon-based resin, acryl-based resin and urethane while having a shape corresponding to that of PDP **20** or chassis base **22**. A plurality of prominent portions ***24a*** are provided at the side of heat conductive medium **24** contacting either PDP **20**.

[0034] Prominent portions ***24a*** of heat conductive medium **24** are formed as a in a series longitudinally parallel convex portions. As shown in **FIG. 2**, depressed portions ***24b*** are disposed between prominent portions ***24a*** while having a shape varied depending upon the curvature of prominent portions ***24a***. Prominent portions ***24a*** are closely adhered to PDP **20**.

[0035] Furthermore, contact area enlargement members are formed at each prominent portion ***24a*** to enhance the adhesive strength of heat conductive medium **24** to PDP **20**. In this embodiment, the contact area enlargement members form a comb teeth pattern ***24c***, created by periodically spaced grooves along each of the series of longitudinally parallel convex portions as shown in **FIG. 2**, or by diamond-like patterns as shown in **FIG. 3A**.

[0036] Alternatively, as shown in **FIG. 3B**, a plurality of different-shaped patterns ***24c*** may be made at respective prominent portions ***24a***.

[0037] The heat conductive medium **24** is installed between PDP **20** and chassis base **22** as follows.

[0038] As shown in **FIG. 4A**, heat conductive medium **24** is attached to bottom side ***22a*** of chassis base **22**, such that air is not present between heat conductive medium **24** and chassis base **22**.

[0039] Thereafter, double-faced tape **26** is attached to the bottom side of chassis base **22** around the periphery of heat conductive medium **24**.

[0040] As shown in **FIG. 4B**, when chassis base **22** is combined with PDP **20** such that prominent portions ***24a*** of heat conductive medium **24** are closely adhered to top side ***20a*** of PDP **20**, a predetermined pressurizing power is applied to chassis base **22** from the top. As the side of heat conductive medium **24** with prominent portions ***24a*** is increased in the contact area by way of patterns ***24c***, it can be more easily attached to top side ***20a*** of PDP **20**.

[0041] As shown in **FIG. 4C**, prominent portions ***24a*** are pressed toward depressed portions ***24b*** while being deformed in shape. Consequently, depressed portions ***24b*** are flattened while allowing the air therein to escape to the outside. Double-faced tape **26** engages PDP **20**. Accordingly, heat conductive medium **24** can be attached to the top side of PDP **20** without forming any gap between them.

[0042] As described above, heat conductive medium **24** is attached to PDP **20** and chassis base **22** while being positioned between them without forming any gap so that the heat conduction rate is enhanced while effectively dissipating the heat generated at PDP **20** to the outside.

[0043] **FIG. 5** is a cross sectional view of a plasma display device according to a second embodiment of the present invention.

[0044] As shown in **FIG. 5**, the plasma display device includes PDP **30**, chassis base **32**, and heat conductive medium **34** disposed between PDP **30** and chassis base **32**. The basic structure of PDP **30**, chassis base **32** and heat conductive medium **34** is the same as that related to the first embodiment except that reinforcing member **36** is provided to reinforce the hardness of heat conductive medium **34**.

[0045] When heat conductive medium **34** is attached to PDP **30** and chassis base **32**, a separator such as vinyl and film is separated from both sides of heat conductive medium **34**. At this time, reinforcing member **36** makes it easy to perform the separation while maintaining the original shape of soft material-based heat conductive medium **34** in a stable manner.

[0046] That is, conventionally, the heat conductive medium is coated with a separator before the attachment process. When the separator is separated from the soft material-based heat conductive medium, it is difficult to make the separation operation while keeping the original shape of the heat conductive medium in a stable manner. In this case, the heat conductive medium is not easily attached to the panel and the chassis base.

[0047] Reinforcing member **36** compensates for such a shortcoming. Reinforcing member **36** may be formed with micro fibers or micro metals built in heat conductive medium **34**. The overall pattern of reinforcing member **36** is preferably formed in a parallel shape as shown in **FIG. 6A**, or a lattice shape as shown in **FIG. 6B**.

[0048] As described above, in this second embodiment, reinforcing member **36** is built in heat conductive medium **34** such that it can form the frame of heat conductive medium **34**. In this way, the possible device failure due to the softness of heat conductive medium **34** can be prevented.

[0049] **FIG. 7** is a cross sectional view of a plasma display device according to a third embodiment of the present invention. In this embodiment, when the heat conductive medium is provided between the PDP and the chassis base, the possible gap between the contact sides can be removed.

[0050] Specifically, the plasma display device includes PDP **40**, chassis base **42**, and heat conductive medium **44** disposed between PDP **40** and chassis base **42**. Furthermore, liquid phase (such as a gel-state) heat conductive member **46** is provided at depressed portions ***44a*** of heat conductive medium **44**. Gel-state heat conductive member **46** helps prevent left over air in depressed portions ***44a*** deteriorating the heat conductive rate of heat conductive medium **44** when heat conductive medium **44** is attached to PDP **40**. Heat conductive member **46** is preferably formed with thermal grease. That is, in the presence of heat conductive member **46** provided between depressed portions ***44a***, when heat conductive medium **44** is attached to PDP **40**, heat conductive member **46** occupies the gap between prominent portions ***44b*** of heat conductive medium **44** while allowing the air therein to escape to the outside. Consequently, the heat dissipation efficiency of the resulting display device can be enhanced depending upon the heat conduction degree of heat conductive medium **44** as well as that of heat conductive member **46**. The heat conductive member **46** may be selectively provided either at PDP **40** or at heat conductive medium **44** while being positioned at depressed portions ***44a***.

[0051] In order to form the contact area enlargement patterns at the prominent portions of the heat conductive medium, a frame with a shape corresponding to the relevant pattern may be pressed onto the target material for the heat conductive medium, or a separate patterning unit with the relevant pattern may be prepared, and attached to the target material for the heat conductive medium.

[0052] **FIG. 8** is a partial perspective view of a heat conductive medium according to a fourth embodiment of the present invention.

[0053] As shown in **FIG. 8**, heat conductive medium **54** has a plurality of prominent portions ***54a***, and depressed portions ***54b*** disposed between prominent portions ***54a***. Contact area enlargement members are provided at the surface of prominent portions ***54a*** by a plurality of patterns ***54c***. Furthermore, a plurality of holes ***54d*** are formed at prominent portions ***54a*** such that they pass through prominent portions ***54a***.

[0054] The holes ***54d*** are arranged at prominent portion ***54a*** while being spaced apart from each other at a predetermined distance. Preferably, holes ***54d*** may be uniformly arranged at the entire surface of heat conductive medium **54** including depressed portions ***54b***.

[0055] In this embodiment, holes ***54d*** are arranged at grooves ***54e*** outlining patterns ***54c***, holes ***54d*** being of a circular shape. In this case, the diameter of each hole is established to be about 0.1-2 mm. This is determined in consideration of the pressurizing power applied to heat conductive medium **54** in combination with the chassis base and the PDP. In the presence of such holes, the overall area of the heat conductive medium becomes reduced so that it suffers relatively small pressurizing power during the combination.

[0056] Holes ***54d*** may be formed by pressing heat conductive medium **54** using a press with pins corresponding to holes ***54d***, or through rolling heat conductive medium **54** by way of a roller with the pins.

[0057] **FIG. 9** illustrates a variation in heat conductive medium **54** according to the fourth embodiment of the present invention.

[0058] The process of forming heat conductive medium **54** between the PDP and the chassis base will be now explained in detail.

[0059] As shown in **FIG. 10A**, heat conductive medium **54** is attached to bottom side ***56a*** of chassis base **56**. The attachment may be made by way of a squeeze while not forming a gap between heat conductive medium **54** and chassis base **56**.

[0060] Thereafter, a combination member such as a double-faced tape **58** is provided at the attachment side of

chassis base **56**. As shown in **FIG. 10B**, when chassis base **56** is aligned with PDP **60** such that prominent portions **54***a* of heat conductive medium **54** contact attachment side **60***a* of PDP **60**, a predetermined pressurizing power is applied to chassis base **56** from the top.

[0061] The pressurizing power may be reduced due to the presence of holes **54***d*. When heat conductive medium 54 is pressurized onto attachment side **60***a* of PDP **60**, the pressurizing power spreads onto the entire surface of prominent portions **54***a* while pressurizing holes **54***d*.

[0062] Accordingly, holes **54***d* are contracted toward their centers while removing the internal empty space. The air filled in the empty space of holes **54***d* is extracted to depressed portions **54***b* through grooves **54***e*.

[0063] As shown in **FIG. 10C**, prominent portions 54*a* are deformed from their original shape while being pressed to the side of depressed portions **54***b*, and depressed portions **54***b* are removed by way of prominent portions **54***a* while allowing the air therein to escape to the outside.

[0064] Consequently, heat conductive medium 54 can become attached to the PDP while avoiding any gap between them. That is, the attachment is enhanced by way of holes **54***d* at heat conductive medium **54**.

[0065] As described above, in the inventive plasma display device, the attachment of the heat conductive medium to the PDP or the chassis base may be made in an effective manner while enhancing the heat conduction rate of the heat conductive medium and reliability of the resulting product.

[0066] Accordingly, a separate heat dissipate member such as a cooling fan is no longer required in the inventive plasma display device so that possible noise due to the cooling fan can be prevented.

[0067] While the present invention has been described in detail with reference to the certain embodiments, those skilled in the art will appreciate that various modifications and substitutions can be made thereto without departing from the spirit and scope of the present invention. For example, referring to **FIG. 11**, the inventive structural components and its method of manufacture hereinbefore described may be provided on a side of the heat conductive medium such that the chassis base rather than the PDP is in contact with the inventive side of the heat conductive medium having the prominent portions. Similarly, as can be seen in **FIG. 12**, both sides of the heat conductive medium can implement the inventive structural components such that both the PDP and the chassis base can be in contact with an inventive side of the heat conductive medium having the prominent portions.

What is claimed is:

1. A plasma display device comprising:

a plasma display panel;

a chassis base proceeding substantially parallel to the plasma display panel; and

a heat conductive medium closely adhered to the plasma display panel and the chassis base while being disposed between the plasma display panel and the chassis base;

wherein a side of the heat conductive medium facing the plasma display panel and/or the chassis base is provided with a plurality of prominent portions, depressed portions being disposed between the prominent portions to remove a gap between the heat conductive medium and the respective plasma display panel and/or chassis base, and contact area enlargement members being formed at the prominent portions to improve the attachment efficiency of the heat conductive medium to the plasma display panel.

2. The plasma display device of claim 1, wherein the prominent portions of the heat conductive medium include a plurality of longitudinally parallel convex portions.

3. The plasma display device of claim 1, wherein a contact area enlargement member is formed by a three-dimensional pattern, each contact area enlargement member being separated from each other by a groove.

4. The plasma display device of claim 3, wherein the three-dimensional pattern is diamond-like shaped.

5. The plasma display device of claim 3, wherein the three-dimensional portion is comb teeth shaped.

6. The plasma display device of claim 1, wherein a gel-state heat conductive member is formed at the depressed portions.

7. The plasma display device of claim 6, wherein the gel-state heat conductive member is formed with grease.

8. The plasma display device of claim 1, further comprising a reinforcing member formed in the heat conductive medium to reinforce the hardness of the heat conductive medium.

9. The plasma display device of claim 8, wherein the reinforcing member is formed by micro fibers built into the heat conductive medium in a predetermined pattern.

10. The plasma display device of claim 8, wherein the reinforcing member is formed by micro metals built into the heat conductive medium in a predetermined pattern.

11. The plasma display device of claim 1, further comprising a plurality of holes passing through the prominent portions.

12. The plasma display device of claim 11, wherein the holes are arranged located along grooves separating the contact area enlargement members of the prominent portions.

13. The plasma display device of claim 11, wherein the holes are of a circular shape.

14. A heat conductive apparatus for a plasma display device having a plasma display panel substantially parallel to a chassis base, the heat conductive apparatus comprising:

a heat conductive medium installable between the plasma display panel and the chassis base;

wherein a side of the heat conductive medium facing the plasma display and/or chassis base is provided with a plurality of prominent portions, depressed portions being disposed between the prominent portions to remove a gap between an installed heat conductive medium and the respective plasma display panel and/or chassis base, and contact area enlargement members being formed at the prominent portions to improve the attachment efficiency of the installed heat conductive medium to the respective plasma display panel and/or chassis base.

15. The heat conductive apparatus of claim 14, wherein the prominent portions of the heat conductive medium include a plurality of longitudinally parallel convex portions.

16. The heat conductive apparatus of claim 14, wherein a contact area enlargement member is formed by a three-dimensional pattern, each contact area enlargement member being separated from each other by a groove.

17. The heat conductive apparatus of claim 16, wherein the three-dimensional pattern is diamond-like shaped.

18. The heat conductive apparatus of claim 16, wherein the three-dimensional pattern is comb teeth shaped.

19. The heat conductive apparatus of claim 14 a gel-state heat conductive member is formed at the depressed portions.

20. The heat conductive apparatus of claim 19, wherein the gel-state heat conductive member is formed with grease.

21. The heat conductive apparatus of claim 14, further comprising a reinforcing member formed in the heat conductive medium to reinforce the hardness of the heat conductive medium.

22. The heat conductive apparatus of claim 21, wherein the reinforcing member is formed by micro fibers built into the heat conductive medium in a predetermined pattern.

23. The heat conductive apparatus of claim 21, wherein the reinforcing member is formed by micro metals built into the heat conductive medium in a predetermined pattern.

24. The heat conductive apparatus of claim 14, further comprising a plurality of holes passing through the prominent portions.

25. The heat conductive apparatus of claim 24, wherein the holes are arranged located along grooves separating the contact area enlargement members of the prominent portions.

26. The heat conductive apparatus of claim 24, wherein the holes a circular shape.

* * * * *

APPENDIX I

US006161910A

United States Patent [19]

Reisenauer et al.

[11] **Patent Number: 6,161,910**

[45] **Date of Patent: Dec. 19, 2000**

[54] **LED READING LIGHT**

[75] Inventors: **William E. Reisenauer,** Commack; **Jennifer L. Gloisten,** Farmingville; **Tolek Pawelko,** Deer Park, all of N.Y.

[73] Assignee: **Aerospace Lighting Corporation,** Holbrook, N.Y.

[21] Appl. No.: **09/460,877**

[22] Filed: **Dec. 14, 1999**

[51] **Int. Cl.**^{7} **G05F 1/00**

[52] **U.S. Cl.** **316/309**; 315/312; 315/158; 315/224; 362/800; 362/235

[58] **Field of Search** 315/309, 312, 315/158, 224, 112; 362/800, 235, 227, 240, 294, 373

[56] **References Cited**

U.S. PATENT DOCUMENTS

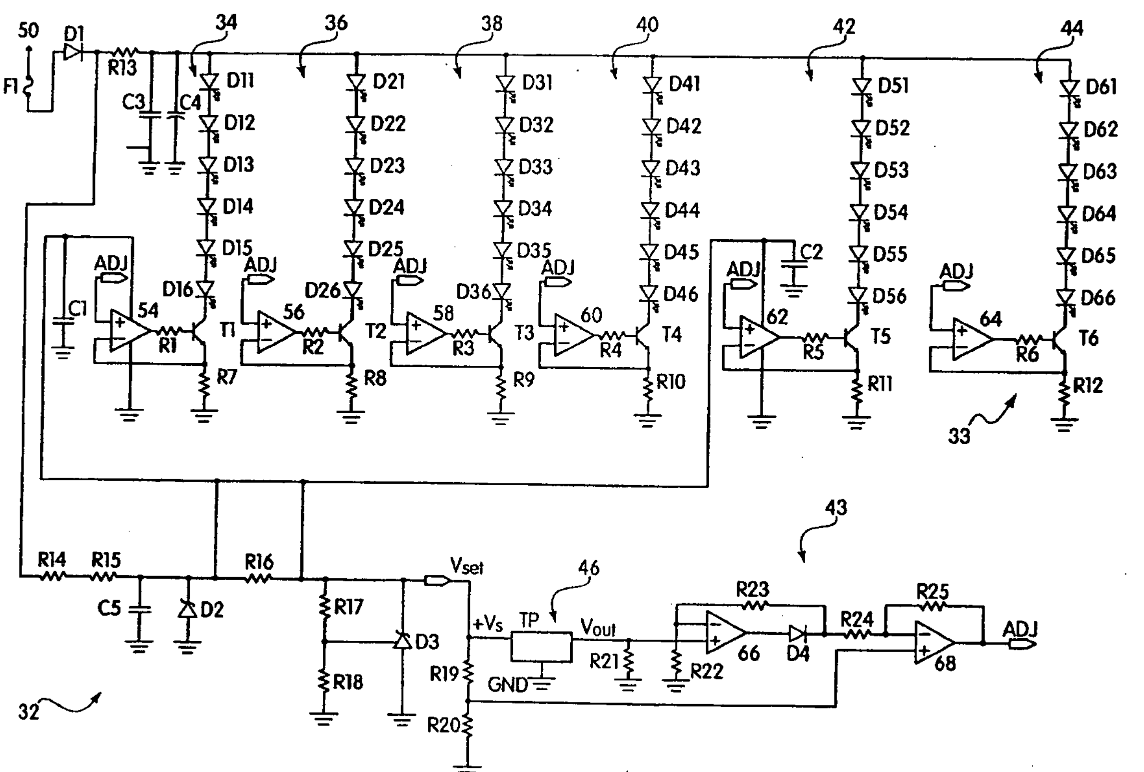
4,947,291	8/1990	McDermott	362/19
4,963,798	10/1990	McDermott	315/312
5,038,255	8/1991	Nishihashi et al.	362/61
5,390,092	2/1995	Lin	362/235
5,580,163	12/1996	Johnson, II	362/285
5,632,551	5/1997	Roney et al.	362/249
5,765,940	6/1998	Levy et al.	362/240
5,782,555	7/1998	Hochstein	362/373
5,785,418	7/1998	Hochstein	362/373
5,857,767	1/1999	Hochstein	362/294
6,045,240	4/2000	Hochstein	362/294

Primary Examiner—Haissa Philogene
Attorney, Agent, or Firm—Collard & Roe, P.C.

[57] **ABSTRACT**

An LED reading light assembly has an optical assembly, a power circuit board, a housing, and a control system. The optical assembly includes a holographic lens and an LED assembly comprising an LED circuit board and a plurality of LED's disposed on the outward facing side of the LED circuit board. The power circuit board provides a constant source of electric current to power the LED's. The housing includes a housing plate disposed behind the LED circuit board and a black anodized fin plate. The control system includes a temperature protection circuit monitoring the ambient temperature at the LED assembly during operation and adjusting the power supplied to the LED's to maintain the ambient temperature within a selected temperature range.

11 Claims, 4 Drawing Sheets



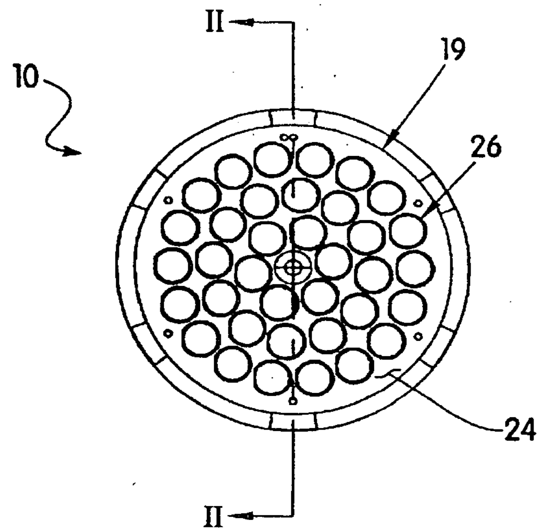


FIG. 1

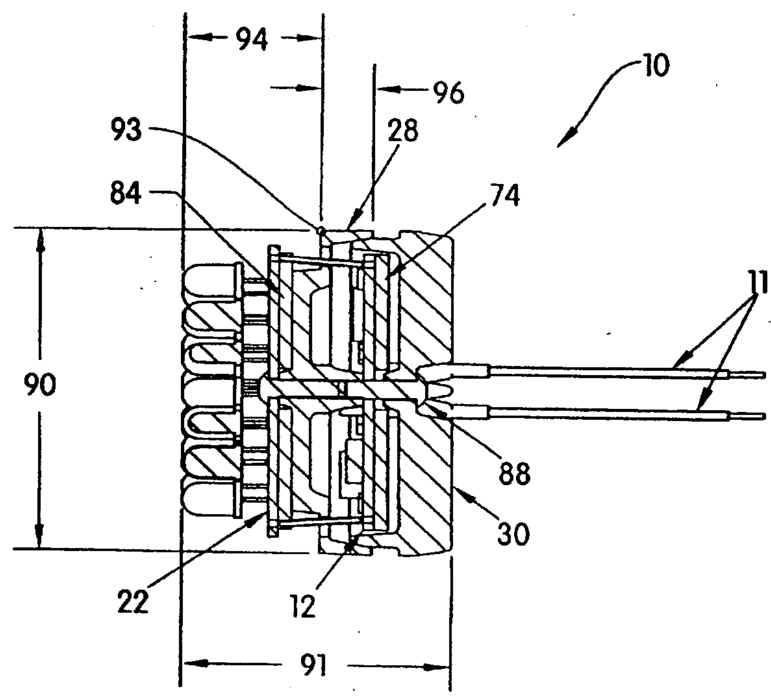


FIG. 2

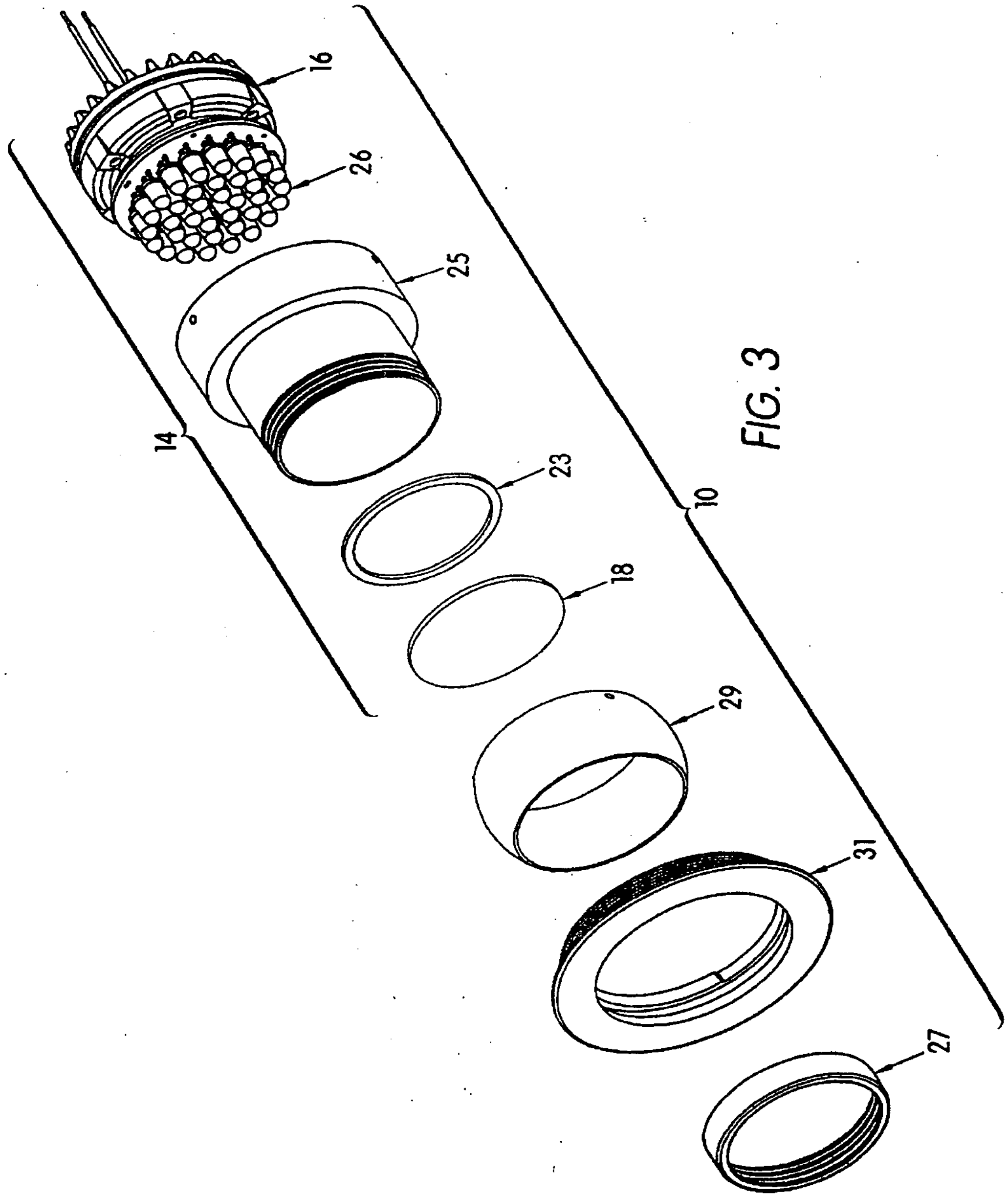


FIG. 3

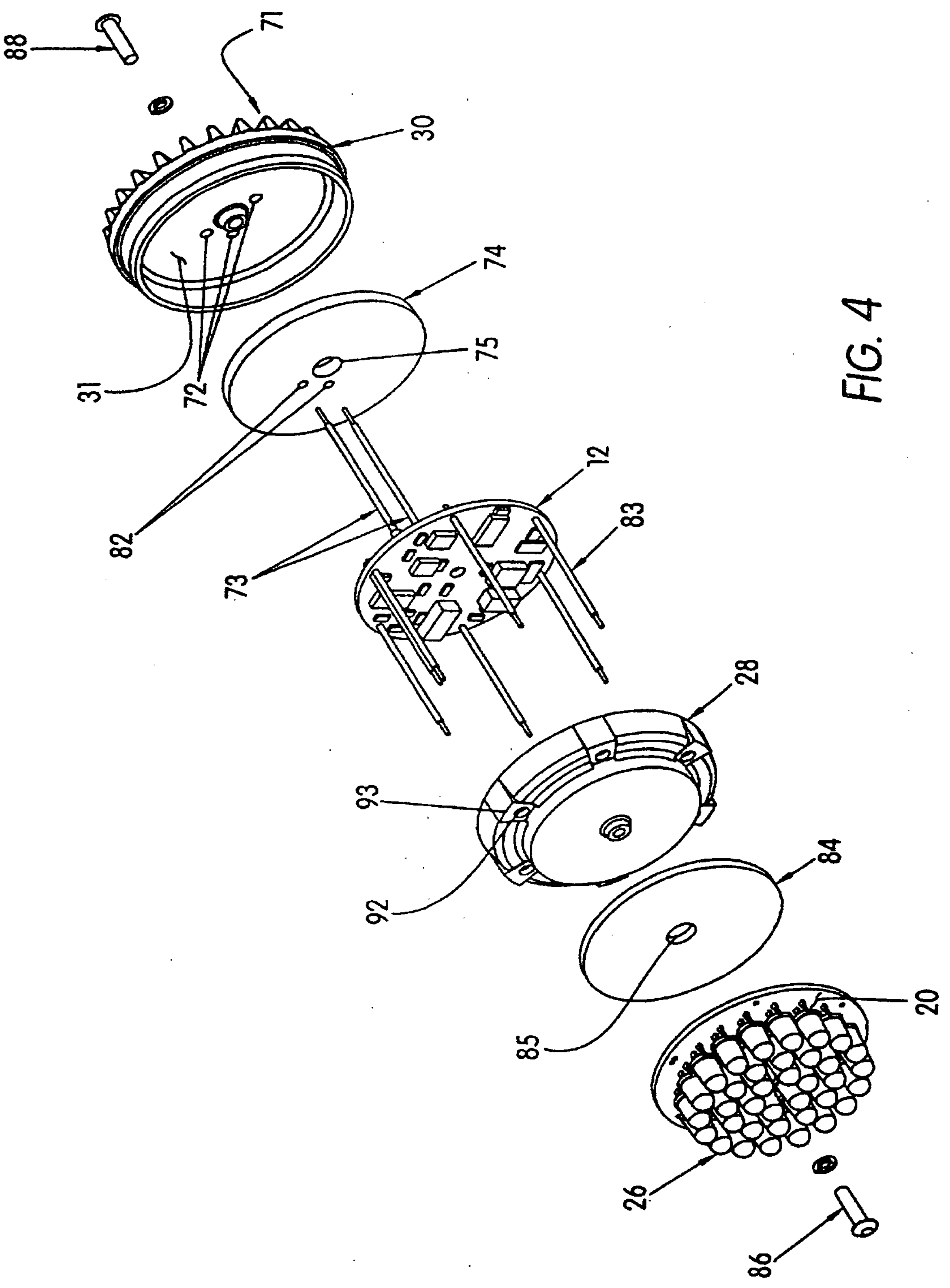
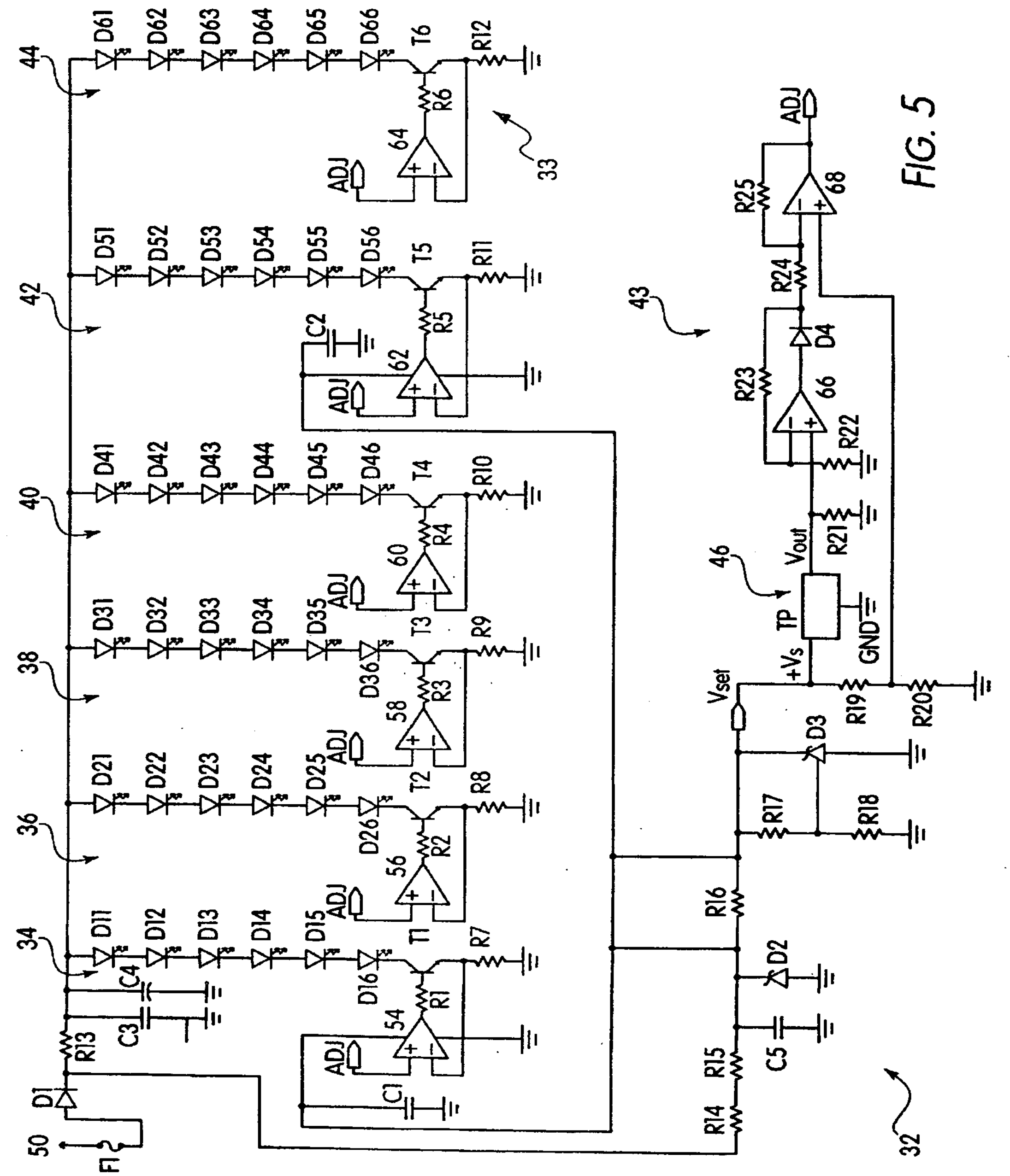


FIG. 4


50
F1
D1
R13
C3
C4
C1
C2
C5
34
36
38
40
42
44
43
46
32
33
D11
D12
D13
D14
D15
D16
D21
D22
D23
D24
D25
D26
D31
D32
D33
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R10
R11
R12
54
56
58
60
62
64
66
68
ADJ
R14
R15
R16
R17
R18
R19
R20
R21
R22
R23
R24
R25
D2
D3
D4
V_{set}
$+V_s$
TP
GND
V_{out}

FIG. 5

LED READING LIGHT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to reading lights and more particularly a light emitting diode (LED) reading light assembly suitable for use in aviation applications.

2. The Prior Art

It is known to use white LED's as a light source for illumination purposes. For example, U.S. Pat. No. 4,947,291 to McDermott relates to a device for cockpit lighting including a filter for adjustable proportional dimming of the emitted white light from LED's. U.S. Pat. No. 4,963,798 relates to a white LED illumination device which uses the resistance of an incandescent lamp element as a current limiting resistor to protect the LED from excessive current.

It is also known to use a thermally conductive housing to prevent heat from accumulating in the chamber housing the LED lamp. For example, U.S. Pat. No. 5,038,255 to Nishihashi et al. discloses a vehicle lamp having a housing made of synthetic resin to improve heat conductivity, a lens and a plurality of LED's placed on a long light source fixing face member. The light source fixing face is provided on the inner face of the housing so that heat can be effectively disbursed directly to the atmosphere. Similarly, Roney et al, U.S. Pat. No. 5,632,551 discloses an LED vehicle lamp assembly such as for truck trailers or tractors having LED's mounted to a circuit board inside a housing filled with a resin for conducting excess heat to the outside environment. The housing is preferably formed of anodized aluminum to promote heat transfer and to minimize corrosion. See also U.S. Pat. Nos. 5,782,555; 5,785,418 and 5,857,767 to Hochstein. The Hochstein '555 and '418 patents disclose an LED lamp assembly including a thermally conductive plating to conduct heat from the leads of the LED, and a heat sink for conducting heat to the light emitting side of the assembly. The Hochstein '767 patent discloses an LED lamp assembly including an aluminum heat sink formed to include heat radiating fins which dissipate heat.

U.S. Pat. No. 5,765,940 to Levy et al discloses an LED-illuminated stop/tail light assembly for vehicles which includes a lens that is capable of directing light from the LED's both horizontally and vertically. A current regulating assembly mounted within the housing has a first output that provides either a low current level for tail-light mode or a high current level for brake light mode and a second output that provides a current return path. The current regulating assembly maintains steady current through the LED's independent of the power source voltage so as to prevent an overheating of the LED's at higher than normal voltages and to provide consistent non-flickering light output with varying input voltages. The lens includes hyperbolic surfaces and a prismatic lens. See also U.S. Pat. No. 5,580,163 to Johnson, II, which includes a flexible membrane for focusing an LED light source.

Another patent of general interest is U.S. Pat. No. 5,390,092 to Lin which shows a light emitting device receptacle including a housing and a circuit board in the housing to which the LED's are affixed.

A key advantage of LED technology over more conventional light sources, such as incandescent or halogen lamps, is the much higher anticipated life of the LED source. Long lamp life is particularly advantageous in aviation application where lamp replacement is cumbersome and requires the use of highly skilled and certified workers to effect replacement.

Current LED's offer mean time between failure values of approximately 100,000 operating hours compared to 1,000 to 4,000 hours for filament based devices, including incandescent and halogen lamps.

Achieving the predicted longevity of the LED's, however, is predicated upon operating them within their prescribed operating envelopes. For LED's, typical maximum full power operating temperatures are limited to 50 degrees Celsius. Above 50 degrees Celsius, they can be operated although at proportionally reduced power up to approximately 85 degrees Celsius, at which point and above they should be at zero power. Although at the present time there are a large variety of LED assemblies, there is still a need for a highly reliable, long life and low heat dissipation LED reading light assembly that produces the maximum light output over the widest range of ambient temperature conditions.

OBJECTIVES AND FEATURES OF THE INVENTION

It is an objective of the present invention to provide an LED reading light assembly which operates at maximum power to maximize light output over a wide range of ambient temperature conditions, so that it may be used, for example, in aircraft environments for reading light applications.

It is a further objective of the present invention to provide such an LED reading light assembly which addresses each element of thermal management including effective heat transfer, dissipation, and control of internal heat production.

It is a further feature of the present invention to provide an LED reading light assembly which exhibits superior light and life performance characteristics.

SUMMARY OF THE INVENTION

An LED reading light assembly is provided for use, for example, in airborne applications where maintenance costs associated with lamp replacement and the power penalties in light production and cooling make high reliability, long life and low heat dissipation particularly valuable. The LED reading light assembly has an optical assembly, a power circuit board, a housing, and a control system.

The optical assembly has a holographic lens, an optical cavity and an LED assembly. The LED assembly includes an LED circuit board having an outward facing side preferably coated with a reflective white solder mask, and a plurality of LED's, for example fifty (50), disposed on the outward facing side. Preferably, the LED's during operation emit light having a color rendering index of 85 and a color temperature of 5100 degrees Kelvin.

The power circuit board, which is preferably part of a power assembly, is adapted to supply a constant source of electric current to power the LED's. Preferably, a 28 VDC electrical system is electrically connected to the LED reading light assembly.

The housing preferably is constructed of aluminum and has a housing plate disposed behind the LED circuit board and a highly textured, black anodized fin plate. Preferably a cylinder mounted to the LED assembly forms an optical cavity.

The control system includes a temperature protection circuit monitoring the ambient temperature at the LED assembly and adjusting the power supplied to the LED's to maintain the ambient temperature within a selected temperature range based on their prescribed operating envelope.

Preferably, the temperature protection circuit reduces the power to the LED's when the ambient temperature rises above a selected value. The temperature protection circuit preferably includes a plurality of chains of multiple diodes, for example, six-chains of six diodes, with each of the chains driven by a constant source of electric current.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

In the drawings, wherein similar reference characters denote similar elements throughout the several views:

FIG. 1 is a front view of an embodiment of the present invention.

FIG. 2 is a side cross-sectional view taken along section line A—A of FIG.1

FIG. 3 is an exploded perspective view of the embodiment shown in FIG.1 and FIG.2.

FIG. 4 is an exploded perspective view of the housing and LED assembly of FIG. 3.

FIG. 5 is a circuit diagram of a temperature protection circuit incorporated in the LED reading light assembly of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The LED reading light assembly **10** of a preferred embodiment is shown in FIGS. **1–4** and comprises a power assembly including a power circuit board **12**, an optical assembly **14** and a housing **16**. Optical assembly **14** includes a holographic lens **18** and an LED assembly **20**. LED assembly **20** includes an LED circuit board **22** having an outward facing side **24** and a plurality of LED's **26** disposed on outward facing side **24**, which preferably emit white light during operation. Preferably, LED circuit board **22** is circular with a diameter of curvature **19** of 1.900 inches, for example, with 36, 50, or 54 LED's disposed on outward facing side **24**. As shown in FIG. **3**, an optical cavity is formed at the front of LED assembly **20** by an external cylinder **25** preferably mounted to housing **16**. Retaining ring **27** secures holographic lens **18** to cylinder **25** firmly by washer **23**.

Preferably, a ball **29** is movably disposed on external cylinder **25** for directing the light emitted by LED's **26**. In addition, a flange **31** may be assembled to ball **29** for mounting within the aircraft. Use of holographic lens **18** enables the reading light to integrate the light produced by the individual LED's **26** into an even and continuous light pattern. Light energy is directed by lens **18** into a desired geometric region so that the maximum light energy is delivered to the work surface. Preferably, a 10 degree holographic lens is used having a thickness of 0.062 inches, for example. The optical cavity formed by external cylinder **25** provides the focal range for holographic lens **18**. Preferably, a reflective white solder mask coating is applied to outward facing side **24** of LED circuit board **22**, which contributes to the performance of the optical cavity.

As will be appreciated by those skilled in the art, by selection of appropriate LED components, with the assembly of the present invention, light quality, notably the high Color Rendering Index (CRI) of 85 and the desirable color temperature of 5100 degrees Kelvin, can be achieved, which is unparalleled in other LED applications.

Housing **16** provides mechanical protection and structural support for the LED, power, and optical assemblies. Preferably, housing **16** is constructed of aluminum and designed to ensure that LED reading light assembly **10** will withstand the full range of shock, vibration, temperature, and humidity as required for airborne applications.

As shown in FIG. **4**, housing **16** comprises a front heat sink comprising a housing plate **28**, preferably circular, disposed behind LED assembly **20** and a back heat sink comprising a black anodized fin plate **30** which may be highly textured.

Fin plate **30** has a circular recess **31** on one side and a radially finned surface **71** on the other side. A plurality of wire receiving apertures **72** extend through fin plate **30** for receipt of wires **73** extending from power circuit board **12** and electrically connected to a power source.

A soft, circular, thermally conductive pad **74** is received within recess **31** of fin plate **30**. Thermal pad **74** also has a plurality of wire receiving apertures **82** aligned with apertures **72** of fin plate **30** and extending through thermal pad **74**.

Power printed circuit board **12** is disposed on the side of thermal pad **74** opposite to fin plate **30**. A plurality of wires **73** extends from one side of power circuit board **12** and are received by wire receiving apertures **82**, **72** of thermal pad **74** and fin plate **30**.

Front circular heat sink **28** is mounted to power printed circuit board **12** and has a plurality of wire receiving apertures **92** along its circumference **93** for receipt of a plurality of wires **83** extending from the side of LED circuit board **22** opposite to the side having LED's **26** disposed thereon. A front thermal pad **84** is mounted to one side of front heat sink **28** between LED circuit board **22** and front heat sink **28**.

A plurality of fasteners **86**, **88**, for example, screws and washers, mount the various components together. Fastener **86** mounts LED circuit board **22** and front thermal pad **84** to one side of front heat sink **28** through opening **85** of front thermal pad **84**. Fastener **88** mounts back heat sink **30**, back thermal pad **74**, and power printed circuit board **12** to the other side of front heat sink **28** through opening **75** in back thermal pad **74**.

LED reading light assembly **10** is preferably formed compact in size. Referring to FIG. **2**, assembly **10** has an overall height **90** and an overall length **91** from the front of LED's **26** to the end of fin plate **30**, which are 2.00 inches and 1.550 inches respectively, for example. The distance **94** between the front of LED's **26** to circumference **93** of housing plate **28** is 0.800 inches, for example, and the distance **96** from circumference **93** to the end of housing plate **28** is 0.290 inches, for example.

Heat generated by LED assembly **20** is transferred via conduction to housing plate **28**. From there, it flows radially outward to external cylinder **25** and then rearward. The black anodized fin plate **30** facilitates radiant heat transfer from the back of assembly **10**, cooling both the LED and power assemblies. In contrast, conventional incandescent or halogen designs produce significantly greater heat energy and require large orifices and circulating air for adequate cooling.

The power assembly contains the bulk of the electronic intelligence for the device. A constant current source powers the LED's, enabling the reading light to provide a steady

optimum light output over large fluctuations of input voltage, and also illuminates the individual LED's.

LED reading light assembly includes a control system comprising a temperature protection circuit 32 shown in FIG. 5 to promote LED longevity in adverse heat environments. Temperature protection circuit 32 continuously monitors the ambient temperature at LED assembly 20 and reduces the power to LED's 26 when their temperature rises above a selected value, for example, the rated continuous values of the LED's.

As shown in FIG. 5, temperature protection circuit 32 comprises an electrical driving circuit 33, a temperature compensating circuit 43, and a temperature sensing device 46. Driving circuit 33 is electrically connected to a power supply 50 through fuse F1, diode D1 and resistor R13. Temperature compensation circuit 43 and temperature sensing device 46 are provided with a stable voltage reference through diode D3 and resistors R16, R17 and R18. Temperature protection circuit 43 also includes diode D2, resistors R14 and R15, and other devices whose function is to protect the circuit from abnormal aircraft power surges.

Driving circuit 33 includes 36 diodes (LED's), D11–D16, D21–D26, D31–D36, D41–D46, D51–D56, and D61–D66 in six chains 34, 36, 38, 40, 42, and 44 of six diodes each. Each six diode chains 34, 36, 38, 40, 42 and 44 connects to the collector of a respective transistor T1–T6. Under normal operating conditions, electrical circuit 33 drives the diodes with a constant current source established in the transistor's emitter circuit via the respective transistor's fixed emitter resistor R7–R12 and a signal generated by temperature compensation circuit 43. An operational amplifier 54, 56, 58, 60, 62, 64 drives the base of each transistor T1–T6 and maintains a fixed voltage across each emitter resistor R7–R12 that is proportional to the temperature compensation signal. This controlled voltage in the emitter circuit produces the controlled current in the collector circuit of transistors T1–T6.

Temperature compensation circuit 43 includes operational amplifiers 66 and 68 and diode D4. Temperature sensing device 46, such as an Analog Devices part number TMP37, converts temperature data between 5 degrees Celsius and 100 degrees Celsius to a proportional electrical voltage. Temperature compensation circuit 43 reverse biases diode D4 for voltages of temperature sensing device 46 less than the equivalent of 50 degrees Celsius. With D4 reverse biased, temperature compensation circuit 43 produces a constant output voltage at the output of operational amplifier 68 based solely upon a precise voltage reference D3.

For temperatures about 50 degrees Celsius, diode D4 becomes forward biased. As temperatures, and therefore equivalent voltages increase, the output of operational amplifier 66 continues to increase, consequently driving the output of operational amplifier 68 proportionally lower. The closed loop system continuously monitors the diode temperature and adjusts the operating power until an equilibrium is reached. As temperatures approach 85 degrees Celsius, the diode power approaches zero.

In this way, LED reading light assembly 10 continuously monitors the operating temperature of the LED's and adjusts the input power to maintain maximum illumination over all ambient temperature conditions. Temperature compensation circuit 43 emulates the complex, piecewise linear transfer characteristics of the LED's. Below 50 degrees Celsius, the LED's operate at full continuous power yielding maximum light output. Given the efficient thermal dissipation characteristics of the design, LED reading light assembly 10 will produce maximum illumination for most operating ambient conditions. Under unusual high temperature situations, the circuit will adjust the power provided to the LED's to the diodes from excess heat.

Reading light assembly 10 preferably operates from standard 28 VDC electrical systems preferably through electrical contacts 11, such as a plurality of wires, preferably two, extending to a two-pin connector. Operation is similar in most aspects to conventional style lamps. Assembly 10 is preferably designed such that it may be installed in a variety of decorative fixtures without regard to the thermal properties of the fixture.

While preferred embodiments of the present invention have been shown and described, it is to be understood that many changes and modifications may be made hereunto. Without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. An LED reading light assembly comprising:
(a) An optical assembly comprising:
(i) a holographic lens:
(ii) an LED assembly comprising an LED circuit board having an outward facing side and a plurality of LED's disposed on the outward facing side, said LED assembly having an ambient temperature during operation
(b) a power circuit board adapted to supply a constant source of electric current to power the LED's;
(c) a housing comprising
(i) a housing plate disposed behind the LED circuit board;
(ii) a black anodized fin plate; and
(d) a control system comprising a temperature protection circuit monitoring the ambient temperature at the LED assembly and adjusting the power supplied to the LED's to maintain the ambient temperature within a selected temperature range.

2. An LED reading light assembly according to claim 1 further comprising an optical cavity formed by a cylinder mounted to the LED assembly.

3. An LED reading light assembly according to claim 1 wherein the temperature protection circuit reduces the power to the LED's when the ambient temperature rises above a selected value.

4. An LED reading light assembly according to claim 1 wherein a reflective white solder mask coating is applied to the outward facing side of the LED circuit board.

5. An LED reading light assembly according to claim 1 wherein the temperature protection circuit comprises a temperature sensing device and a plurality of chains of a plurality of LED's, each of said chains providing a constant source of electric current.

6. An LED reading light assembly according to claim 1 wherein the temperature protection circuit comprises a temperature sensing device and six chains of six LED's, each of said chains providing a constant current source.

7. An LED reading light assembly according to claim 1 comprising:
(a) a back heat sink comprising a black anodized fin plate having a circular recess on one side and a radially finned surface on the other side, said fin plate having a plurality of wire receiving apertures extending therethrough;
(b) a soft, circular thermal pad received within the recess of the fin plate, said pad having a plurality of wire-receiving apertures extending through said pad and aligned with the wire-receiving apertures of said fin plate;

(c) a power printed circuit board having a plurality of wires extending from one side of said board and received by the wire-receiving apertures of said thermal pad and said fin plate;

(d) a front circular heat sink mounted to said power printed circuit board, said front heat sink having a plurality of wire-receiving apertures along its circumference;

(e) a front thermal pad mounted to the front heat sink;

(f) an LED circuit board having a plurality of wire's extending from one side of said LED circuit board and received by the wire-receiving apertures of said front heat sink;

(g) a plurality of LED's disposed on the other side of said LED circuit board;

(h) a plurality of fasteners for mounting said back heat sink, said back thermal pad and said power printed circuit board to one side of said front heat sink and for mounting said LED circuit board and front thermal pad to the other side of said front heat sink;

(i) a cylinder mounted to the front heat sink and surrounding the plurality of LED's;

(j) a ball movably disposed on the cylinder for directing the light emitted by the LED's;

(k) a flange mounted to the ball;

(l) a holographic lens mounted within the cylinder; and

(m) a retaining ring mounting the holographic lens within the cylinder.

8. An LED reading light assembly according to claim 1 wherein fifty LED's are disposed on the LED circuit board.

9. An LED reading light assembly according to claim 1 wherein the housing is constructed of aluminum.

10. An LED reading light assembly according to claim 1, wherein the LED's during operation emit light having a color rendering index of 85 and a color temperature of 5100 degrees Kelvin.

11. An LED reading light assembly according to claim 1 wherein the assembly is electrically connected to a 28 VDC electrical system.

* * * * *